

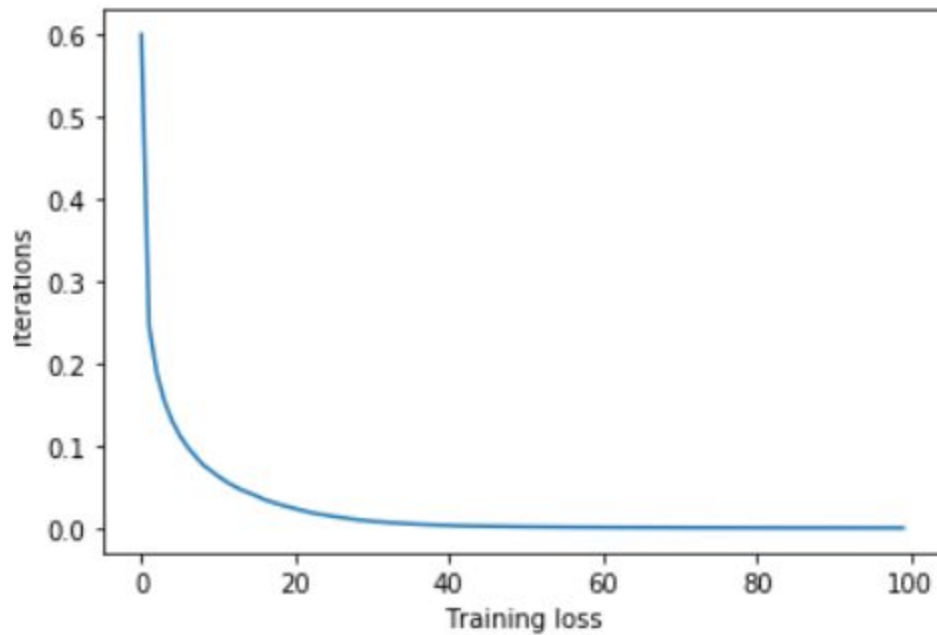
ML Homework Assignment - 3

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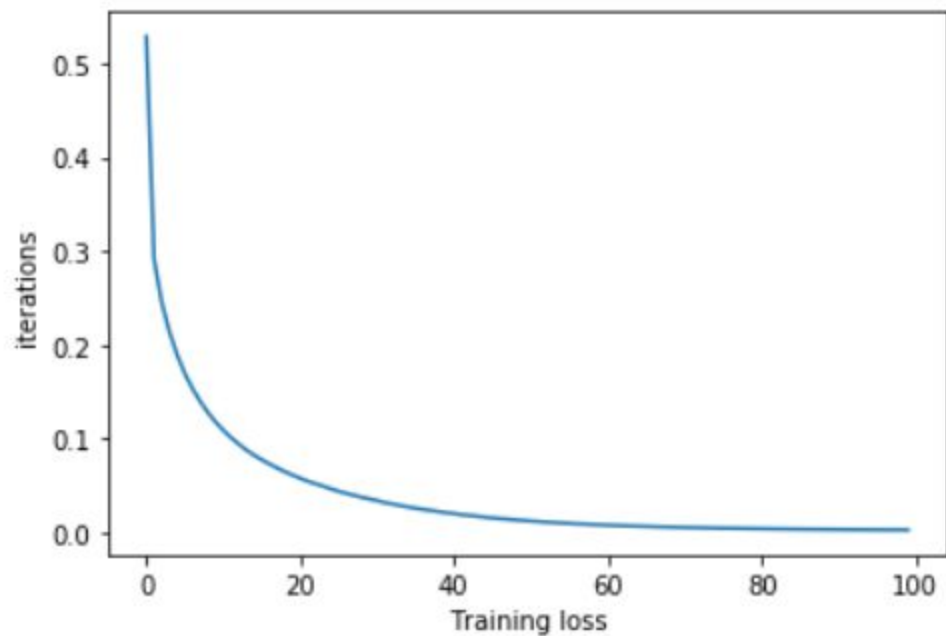
1)

Relu on implemented neural network:



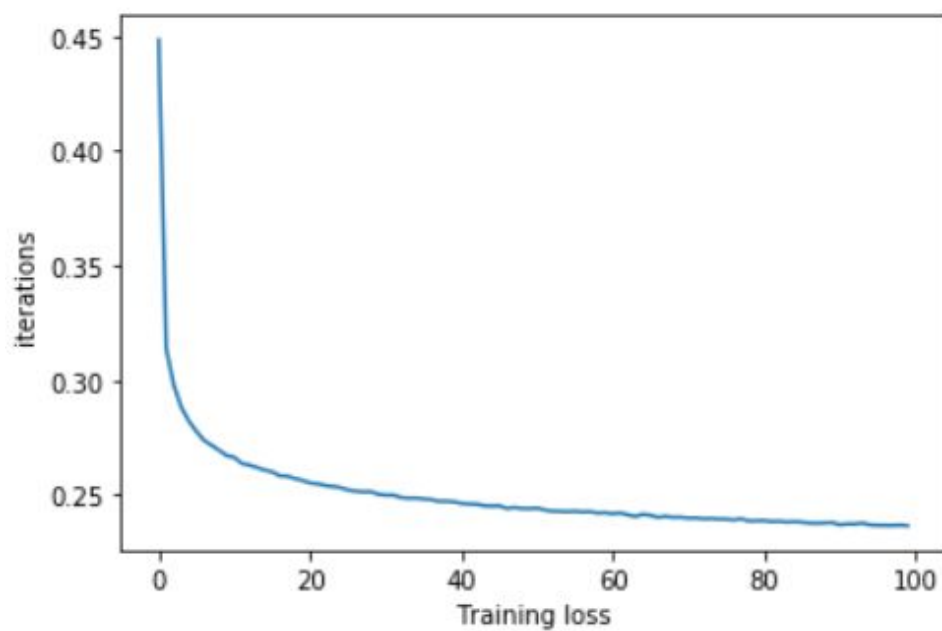
Test set score: 0.9715

Tanh on implemented neural network



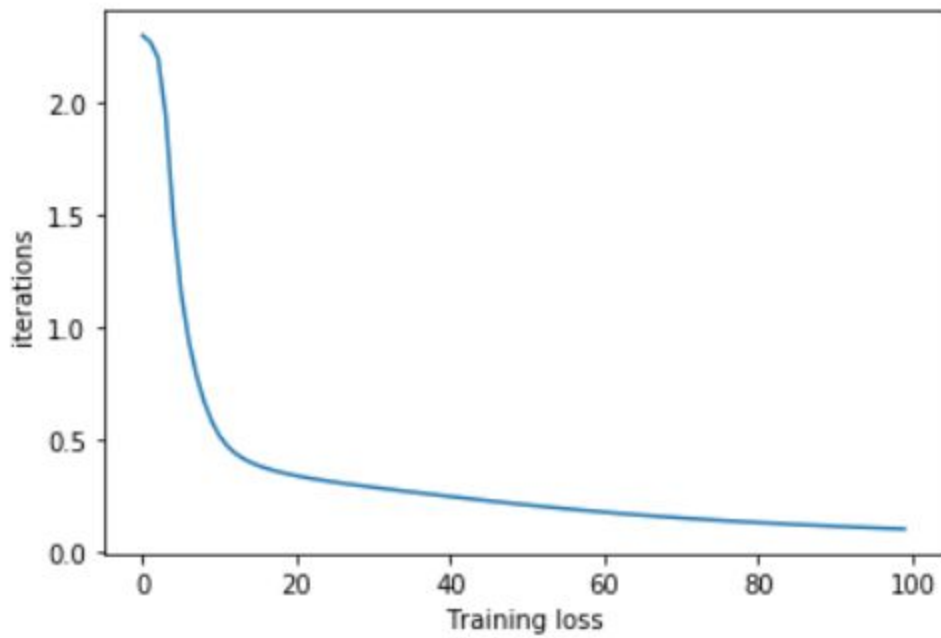
Test set score: 0.9775

linear on implemented neural network



Test set score: 0.9259

Sigmoid on implemented neural network



Test set score: 0.9656

Relu sklearn:

Training set score: 0.999717

Test set score: 0.984100

Tanh sklearn:

Training set score: 1.000000

Test set score: 0.983300

Linear sklearn:

Training set score: 0.921933

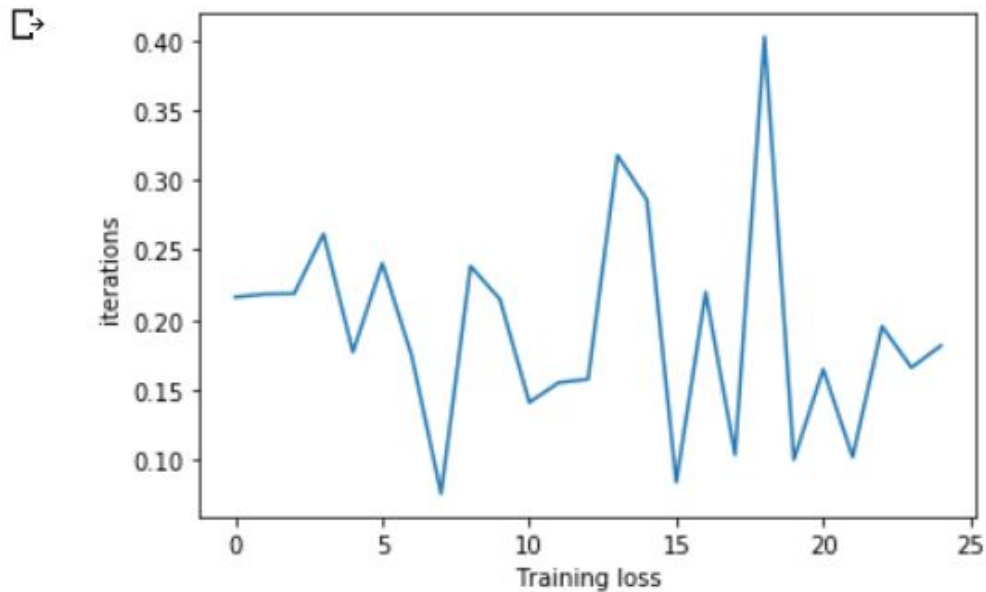
Test set score: 0.910800

Sigmoid sklearn:

Training set score: 1.000000
Test set score: 0.978400

We can see that the inbuilt models perform better than the implemented models. This might be because of slight errors in implementation details. Also, this accuracy difference is quite negligible.

2)
CNN



Training set confusion matrix

```
[ [5377    2  102   47    5    0  459    0    8    0]
[   3 5924    1   51    5    1   15    0    0    0]
[  61    4 5174   22  360    3  374    0    2    0]
[ 146   14   83 5411  133    0  210    0    3    0]
[   6    7  310  104 5101    0  471    0    1    0]
[   1    0    0    0    0 5958    0   19    5   17]
[ 601    2  272   58  258    1 4796    0   12    0]
[   0    0    0    0    0  101    0 5714    9  176]
[  26    1    7    2    9    0   28    0 5927    0]
[   0    0    0    0    0    3    0  126    3 5868]]
```

Training set accuracy: 0.94

Testing set confusion matrix

```

[[816    0   16   19    2    2 137    0    8    0]
 [  1 982    1   11    1    0    2    0    2    0]
 [ 17    0 836    8   66    0   68    0    5    0]
 [ 28    2   12 906   22    0   27    0    3    0]
 [  1    0   77   33 807    0   74    0    8    0]
 [  1    0    0    0    0 969    0   13    0   17]
[107    1   58   33   50    0 731    0   19    1]
 [  0    0    0    0    0    9    0 983    0    8]
 [  2    1    0    2    1    4    2    4 983    1]
 [  0    0    1    0    0    3    0   58    0 938]]

```

Testing set accuracy: 0.8951

SVM:

Hinge loss error on training: 0.258

Hinge loss error on testing: 0.512

svm accuracy on test set is: 0.8132

Confusion Matrix on test set is: [[203 1 5 9 5 3 7 0 1 0]

```

[ 1 231  1 20  8  0  0  0  1  0]
[ 3  0 126  4 46  1 23  0  2  0]
[11  8  4 239 10  3  7  0  1  0]
[ 4  2 39  9 172  1 17  0  0  0]
[ 2  0  0  0  0 217  0 10  7  8]
[33  1 27 11 30  0 131  0  7  0]
[ 0  0  0  0  0 18  0 220  0 12]
[ 0  0  3  4  4 10  0  3 245  2]
[ 0  0  0  0  0  4  0  7  7 249]]

```

svm accuracy on train set is: 0.888

Confusion Matrix on train set is: [[464 2 1 14 6 0 7 0 1 0]

```

[ 2 443  3 23  8  0  0  0  0  0]

```

```
[ 2 1 385 6 70 0 30 0 1 0]
[10 10 4 450 15 0 7 0 0 0]
[ 4 2 48 13 431 1 20 0 2 0]
[ 0 0 0 0 0 458 0 18 5 7]
[44 1 39 15 45 0 350 0 0 0]
[ 0 0 0 0 0 16 0 482 1 18]
[ 1 0 1 3 1 7 2 1 480 3]
[ 0 0 0 0 0 2 0 16 1 497]]
```

The CNN performs a better classification than the SVM. This is mainly because the fully connected softmax layer is more complex than a normal SVM and hence performs better on complex datasets like these.